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'Hobble Creek'— A Superior Selection of Low-Elevation Mountain Big Sagebrush

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RESEARCH SUMMARY

This is the foundation document for the release of the 'Hobble Creek' selection of big sagebrush. It is a low-elevation mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). 'Hobble Creek' is needed to increase the nutrient content of winter diets of mule deer (*Odocoileus hemionus hemionus*) and domestic sheep (*Ovis aries*). This sagebrush exceeds the typical winter forage values in amount of energy-producing compounds, crude protein, phosphorus, and carotene. Of the 186 big sagebrush selections tested, 'Hobble Creek' is the most preferred by wintering mule deer and ranks high in preference by wintering domestic sheep. 'Hobble Creek' does not contain substances that lower grass cell wall digestion in ruminant animals.

'Hobble Creek' can be established and maintained on sites that have deep, well-drained soils with an annual precipitation of at least 14 inches (and preferably more). Soil textures should not be any finer than a clay loam (40 percent clay or less). Soil pH may vary from 6.6 to 8.6.

'Hobble Creek' can be established by direct seeding, by transplanting bareroot or containerized stock, and by a technique we term "mother plant."

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THE NEED

Forages on mule deer (*Odocoileus hemionus hemionus*) and domestic sheep (*Ovis aries*) winter ranges are low in energy, protein, phosphorus, and carotene. This is illustrated in table 1 (common and scientific names in the table and text are from Plummer and others 1977). Most of the forages listed are below the maintenance requirement for these nutrients (National Academy of Sciences 1975). Maintenance requirement is the level of nutrients needed to prevent loss of animal weight. Using in vitro digestibility as a measurement of energy, an in vitro digestibility of about 50 percent is needed for maintenance of wintering mule deer and domestic sheep (Ammann and others 1973). Of the 29 forages listed in table 1, only seven meet the maintenance level with most falling substantially below the maintenance need. The crude protein maintenance requirement for mule deer and sheep is 7.0 to 8.9 percent of dry matter (National Academy of Sciences 1975; Welch and McArthur 1979a). Of the forage species listed in table 1, only 11 meet the required protein maintenance level. The phosphorus maintenance requirement for mule deer and sheep ranges from 0.18 to 0.28 percent of dry matter (National Academy of Sciences 1975; Welch and McArthur 1979a). Only one forage meets the upper level for phosphorus and three meet the lower level. For carotene, the maintenance requirement is 2.0 mg/kg of dry matter (National Academy of Sciences 1975; Welch 1983). Only five forages meet or exceed this need.

Mule deer and domestic sheep winter ranges need forages that supply energy-producing compounds, crude protein, phosphorus, and carotene at or above the maintenance level. Only three forages—fall regrowth of crested wheatgrass (*Agropyron desertorum*), black sagebrush (*Artemisia nova*), and big sagebrush (*Artemisia tridentata*)—exceed the maintenance requirement for energy-producing compounds, crude protein, and carotene. Phosphorus levels of big sagebrush are midrange of the need. Big sagebrush not only can increase the nutrient level of winter diets, but it is a more dependable forage source during periods of drought than are other shrubs, forbs, or grasses (Medin and Anderson 1979; McArthur and Welch 1982).

It is, in part, the evergreen (high leaf-to-twigs ratio) nature of big sagebrush that gives it a winter nutritional advantage over deciduous shrubs such as bitterbrush

(*Purshia tridentata*) and true mountain-mahogany (*Cercocarpus montanus*) and most herbaceous species. Big sagebrush is ecologically adapted to many of our spring-fall-winter ranges (McArthur and Plummer 1978). Big sagebrush usually remains available for use above the snow while the other forage classes become covered and unavailable for wintering animals. Not all big sagebrush populations are equally preferred by wintering animals or are equal in nutritive content (Welch 1983).

What follows is a description of the nutritive profile of 'Hobble Creek', a superior selection of low-elevation mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*).

THE NUTRITIVE PROFILE

In two studies, the 'Hobble Creek' selection was preferred over other selections by wintering mule deer (Welch and others 1981; Welch and McArthur 1986b). This preference is illustrated in table 2. Preference was measured in terms of the percentage of current year's growth removed. Table 2 shows that mule deer from three herds removed significantly greater percentage of the current year's growth from 'Hobble Creek' than from the other 20 selections. A research cooperator testing it against native big sagebrush reported that mule deer in his area (Colorado) heavily favored 'Hobble Creek' (Elderkin 1986).

Preference of wintering domestic sheep for the 'Hobble Creek' selection is illustrated in table 3. The sheep had continual access to high-quality alfalfa hay and 0.75 lb of rolled barley per day per head. The sheep were not starved onto the big sagebrush, but ate big sagebrush by choice. 'Hobble Creek' was in the most preferred group of big sagebrush selections at 80.6 percent of the current year's growth consumed (Welch and others, in press).

Studies show that the productivity of 'Hobble Creek' ranks in the top third of selections tested. Productivity expressed as length of leader growth is illustrated in table 4 (McArthur and Welch 1982; Welch and McArthur 1986a). Of the 21 selections, 'Hobble Creek' ranked seventh and was significantly exceeded only by five selections of *A. tridentata* ssp. *tridentata*. Davis and Stevens (1986) reported that 'Hobble Creek' ranked third out of 20 selections in vegetative production (g/cm of stem).

Winter crude protein content of 'Hobble Creek' is 11 percent of dry matter. This ranks it high among the winter range forages listed in table 1, but as a big sagebrush its crude protein level is below the average of those

Table 1—Winter nutritive value¹ of selected range plants; data expressed as a percentage of dry matter except carotene, which is expressed as milligrams per kilogram of dry matter

Plant name (common and scientific ²)	In vitro digestibility	Crude protein	Phosphorus	Carotene
	Percent			mg/kg
Grasses				
Bearded bluebunch wheatgrass <i>Agropyron spicatum</i>	45.5	3.2	0.05	0.22
Bluestem wheatgrass <i>A. smithii</i>	50.2	3.8	.07	.20
Bottlebrush squirreltail <i>Sitanion hystrix</i>	42.0	4.3	.07	1.10
Crested wheatgrass <i>A. desertorum</i>	43.1	3.5	.07	.20
Crested wheatgrass, fall regrowth <i>A. desertorum</i>	50.6	15.0	.39	432.00
Galleta <i>Hilaria jamesii</i>	48.2	4.6	.08	.40
Idaho fescue <i>Festuca idahoensis</i>	50.5	3.8	.08	—
Indian ricegrass <i>Oryzopsis hymenoides</i>	50.5	3.1	.06	.44
Reed canarygrass <i>Phalaris arundinacea</i>	— ³	7.8	.14	—
Needle-and-thread grass <i>Stipa comata</i>	46.6	3.7	.07	.40
Sandberg bluegrass <i>Poa secunda</i>	—	4.2	—	—
Sand dropseed grass <i>Sporobolus cryptandrus</i>	53.2	4.1	.07	.50
Smooth brome <i>Bromus inermis</i>	47.0	4.1	.12	—
Shrubs				
Antelope bitterbrush <i>Purshia tridentata</i>	23.5	7.6	.14	—
Big sagebrush <i>Artemisia tridentata</i>	57.8	11.7	.22	17.6
Black sagebrush <i>Artemisia nova</i>	53.7	9.9	.18	8.0
Common winterfat <i>Ceratoides lanata</i>	43.5	10.0	.11	16.8
Curlleaf mountain-mahogany <i>Cercocarpus ledifolius</i>	49.1	10.1	—	—
Forage kochia <i>Kochia prostrata</i>	32.2	7.2	—	—
Fourwing saltbush <i>Atriplex canescens</i>	38.3	8.9	—	3.1
Gambel oak <i>Quercus gambelii</i>	26.6	5.3	—	—
Low rabbitbrush <i>Chrysothamnus viscidiflorus</i>	36.0	5.9	.15	—
True mountain-mahogany <i>Cercocarpus montanus</i>	26.5	7.8	.13	—
Rubber rabbitbrush <i>Chrysothamnus nauseosus</i>	44.4	7.8	.14	—
Cliffrose <i>Cowania mexicana</i>	37.6	8.6	—	—
Utah juniper <i>Juniperus osteosperma</i>	44.1	6.6	.18	—
Forbs				
Arrowleaf balsamroot <i>Balsamorhiza sagittata</i>	—	3.6	.06	—

Table 1—(Con.)

Plant name (common and scientific ²)	In vitro digestibility	Crude protein	Phosphorus	Carotene
	----- Percent -----			mg/kg
Oneflower helianthella <i>Helianthella uniflora</i>	—	2.8	.17	—
Small burnet <i>Sanguisorba minor</i>	—	6.6	—	—

¹Values represent the average of a number of studies reported in the literature. References are on file at the Intermountain Research Station's Shrub Sciences Laboratory, Provo, UT.

²Common and scientific names after Plummer and others (1977).

³A bar means no information available.

Table 2—Preference of three wintering mule deer herds for selections of big sagebrush (*Artemisia tridentata*) grown on three geographically separate gardens. Data expressed as a percent of current year's growth eaten. Data points are means for three gardens and 3 years. (Data from Welch and McArthur 1986b)

Selections	Percent of current year's growth eaten
HOBBLE CREEK (v) ¹	57.5 ^{a2}
Colton (v)	47.0 ^b
Petty Bishop's Log (v)	46.0 ^b
Indian Peaks (v)	45.6 ^{bc}
Sardine Canyon (v)	44.6 ^{bc}
Salina Canyon (v)	41.7 ^{bcd}
Durkee Springs (v)	40.7 ^{bcde}
Evanston (w)	40.4 ^{bcde}
Pinto Canyon (v)	40.3 ^{bcdef}
Benmore (v)	39.3 ^{bcdefg}
Clear Creek Canyon (v)	38.4 ^{cdefg}
Milford (w)	37.1 ^{cdefg}
Wingate Mesa (t)	36.4 ^{defgh}
Brush Creek (t)	35.7 ^{defgh}
Dog Valley (t)	33.8 ^{defgh}
Kaibab (w)	33.5 ^{efgh}
Loa (t)	31.6 ^{fgh}
Clear Creek Canyon (t)	31.3 ^{gh}
Dove Creek (t)	30.9 ^h
Trough Springs (w)	30.1 ^h
Evanston (t)	28.3 ^h

¹v = *Artemisia tridentata* ssp. *vaseyana*; t = *A. t.* ssp. *tridentata*; w = *A. t.* ssp. *wyomingensis*.

²Means sharing the same superscript are not significantly different at the 5 percent level.

Table 3—Wintering domestic sheep preference for selections of big sagebrush (*Artemisia tridentata*) grown on three uniform gardens. Data expressed as percent of current year's growth eaten. Data are a summary of three gardens—30 replications per selection. (Data from Welch and others in press)

Selections	Percent of current year's growth eaten
Kaibab (w) ¹	98.3 ^{a2}
Colton (v)	92.3 ^a
Trough Springs (w)	91.1 ^a
Wingate Mesa (t)	85.9 ^{ab}
Milford (w)	82.7 ^{ab}
Brush Creek (t)	81.7 ^{ab}
HOBBLE CREEK (v)	80.6 ^{ab}
Pinto Canyon (v)	76.7 ^b
Sardine Canyon (v)	58.1 ^c
Petty Bishop's Log (v)	48.6 ^{cd}
Evanston (w)	44.2 ^{cde}
Indian Peaks (v)	39.8 ^{cdef}
Clear Creek (v)	21.7 ^{ef}
Benmore (v)	16.7 ^{efg}
Durkee Springs (v)	16.0 ^g
Salina Canyon (v)	10.9 ^g
Dog Valley (t)	4.4 ^g
Clear Creek (t)	1.9 ^g
Evanston (t)	0.5 ^g
Loa (t)	0.0 ^g
Dove Creek (t)	0.0 ^g

¹v = *Artemisia tridentata* ssp. *vaseyana*; t = *A. t.* ssp. *tridentata*; w = *A. t.* ssp. *wyomingensis*.

²Means sharing the same superscript are not significantly different at the 5 percent level.

Table 4—Mean leader lengths of 21 selections of big sagebrush grown on three sites for 5 years (10 plants per selections per site). Data are expressed as centimeters of current year's growth. (Data from Welch and McArthur 1986a)

Selections	Length
	cm
Dove Creek (t) ¹	41.4 ^{a2}
Loa (t)	33.1 ^b
Dog Valley (t)	33.0 ^b
Evanston (t)	30.9 ^c
Clear Creek Canyon (t)	30.8 ^c
Pinto Canyon (v)	23.2 ^d
HOBBLE CREEK (v)	23.1 ^{de}
Salina Canyon (v)	23.0 ^{de}
Indian Peaks (v)	20.9 ^{efg}
Wingate Mesa (t)	20.7 ^{efg}
Kaibab (w)	20.7 ^{efg}
Durkee Springs (v)	20.6 ^{efg}
Sardine Canyon (v)	20.2 ^{fg}
Clear Creek Canyon (v)	18.8 ^{gh}
Benmore (v)	18.8 ^{gh}
Milford (w)	17.2 ^{hi}
Colton (v)	17.2 ^{hi}
Brush Creek (t)	16.7 ^{hi}
Evanston (w)	15.8 ⁱ
Trough Springs (w)	15.5 ⁱ
Petty Bishop's Log (v)	15.3 ⁱ

¹v = *Artemisia tridentata* ssp. *vaseyana*; t = *A. t.* ssp. *tridentata*; w = *A. t.* ssp. *wyomingensis*.

²Means sharing the same superscript are not significantly different at the 5 percent level.

tested (Welch and McArthur 1979b). Its ranking among other selections of big sagebrush is illustrated in table 5. 'Hobble Creek' winter crude protein still exceeds the maintenance requirement (7 to 8.9 percent of dry matter) of mule deer and domestic sheep (National Academy of Sciences 1975; Welch and McArthur 1979a).

Winter in vitro digestibility, an indicator of energy, is 52.6 percent of 'Hobble Creek' dry matter. This ranks it high among the winter range forages listed in table 1, but as a big sagebrush its in vitro digestibility is just below the average of those tested (Welch and Pederson 1981). The ranking of 'Hobble Creek' among other selections of big sagebrush is illustrated in table 6. 'Hobble Creek' in vitro digestibility just exceeds what is thought to be the maintenance requirement (50 percent) for wintering mule deer and domestic sheep (Ammann and others 1973).

Winter level of phosphorus for the selection was 0.21 percent. Even though this is below the upper maintenance requirement of 0.28 percent for wintering mule deer and domestic sheep, it ranks high among other forages (table 1). We have not measured the phosphorus content of other selections of big sagebrush, but based on the data in table 1 for big sagebrush, we believe that 'Hobble Creek' is at least average.

Total winter monoterpenoid (essential or volatile oils) content of 'Hobble Creek' is 2.09 percent of dry matter.

Table 5—Midwinter crude protein content of current year's growth among selections of big sagebrush. Data expressed on a dry-matter basis. No statistical comparisons on a selection basis were made (Welch 1983)

Selections	Percentage of crude protein
Dove Creek (t) ¹	16.0
Clear Creek Canyon (t)	15.3
Evanston (t)	15.2
Dog Valley (t)	14.5
Loa (t)	14.5
Brush Creek (t)	13.1
Evanston (w)	12.9
Wingate Mesa (t)	12.8
Colton (v)	12.0
Kaibab (w)	11.9
Salina Canyon (v)	11.7
Alton (v)	11.3
Milford (w)	11.2
Petty Bishop's Log (v)	11.2
Indian Peaks (v)	11.2
HOBBLE CREEK (v)	11.0
Trough Springs (w)	11.0
Pinto Canyon (v)	11.0
Sardine Canyon (v)	10.5
Durkee Springs (v)	10.0
Benmore (v)	10.0

¹v = *Artemisia tridentata* ssp. *vaseyana*, t = *A. t.* ssp. *tridentata*, w = *A. t.* ssp. *wyomingensis*.

This level is about midrange for other selections of big sagebrush (Welch and McArthur 1979a, Welch and McArthur 1981). The 'Hobble Creek' profile consists of six monoterpenoids (table 7): camphene, 1,8 cineol, camphor, Beta-thujone, fenchyl alcohol, and one unidentified oxygenated-monoterpenoid. Camphor makes up about 55 percent of the total monoterpenoids (table 7). Camphor was followed by 1,8 cineol at 28.7 percent. We have not established a significant relationship between monoterpenoid content and preference (White and others 1982; Pederson and Welch 1985; Welch and others 1983) or between monoterpenoids and digestibility (Welch and Pederson 1981; Pederson and Welch 1982). Hobbs and others (1986) reported that large amounts of 'Hobble Creek' vegetative tissue (80 percent of digestion mixture) did not suppress grass cell wall digestion.

AREAS WHERE IT CAN BE GROWN

The native site of 'Hobble Creek' is east of Springville, UT, at the mouth of the Hobble Creek drainage at an elevation of about 4,600 ft. The breeder plot that defines the selection is a 100- by 100-ft enclosure with a southern exposure and a 20 percent slope. Soil environmental conditions within 100 ft of the enclosure were considered to be part of the selection native site.

Table 6—Winter in vitro digestibility of current year’s growth from 10 selections of big sagebrush. Data expressed on a percentage of dry matter basis. ‘Hobble Creek’ not included in the statistical analysis. Data from Welch and Pederson (1981) and on file at the Intermountain Research Station’s Shrub Sciences Laboratory, Provo, UT.

Selections	Percent digested dry matter
Clear Creek Canyon (t) ¹	64.8 ^{a2}
Dove Creek (t)	64.6 ^a
Loa (t)	57.0 ^b
Indian Peaks (v)	55.8 ^b
Benmore (v)	55.2 ^b
Kaibab (w)	54.9 ^b
Milford (w)	54.6 ^b
HOBBLE CREEK (v)	52.6
Sardine Canyon (v)	48.7 ^{bc}
Trough Springs (w)	44.6 ^c

¹v = *Artemisia tridentata* ssp. *vaseyana*, t = *A. t.* ssp. *tridentata*, w = *A. t.* ssp. *wyomingensis*.
²Means sharing the same superscript are not significantly different at the 5 percent level.

Here the selection grows on six soils: Bingham gravelly loam, Lakewin cobbly fine sandy loam, Lakewin gravelly fine sand loam, Pleasant Grove sandy loam, Pleasant Grove stony loam, and Sterling-Terrance cobbly fine sand. All soils are deep and well drained. They are usually moist but are dry between the depths of 7 and 20 inches for more than 60 consecutive days in the summer. Soil pH ranges from 7.0 to 8.4. These values represent all soils and soil layers. Weathered limestone is the parent material. From 3 to 4 inches of available water is held in these soils to a depth of 5 ft. Roots can penetrate to a depth of 5 ft or more. Average annual precipitation ranges from 14 to 18 inches. The effective precipitation at the breeder plot is probably less than the 14 to 18 inches due to the southern exposure and 20 percent slope. The frost-free period ranges from 130 to 170 days. All soils are moderate to rapidly permeable with moderate natural fertility (Utah State Engineer Office 1931-60; Swenson and others 1972).

‘Hobble Creek’ big sagebrush grows and reproduces on other sites. Two of these sites at which the plant has received substantial testing are Salt Creek Canyon and Gordon Creek Wildlife Management Area. The Salt Creek Canyon site is about 2 miles east of Nephi, UT, at an elevation of about 5,500 ft. It is a basin big sagebrush (*A. t.* ssp. *tridentata*) site. Soil is a Rofiss gravelly clay loam, 4 to 5 percent slope. It is a deep, well-drained alluvial soil derived from Arpien shale. Soil permeability is moderately slow with an effective rooting depth of 5 ft or more. Average annual precipitation ranges from 12 to 16 inches; pH ranges from 8.2 to 8.6. The frost-free period is from 100 to 140 days (Utah State Engineer Office 1931-60; Trickley and Hall 1984).

The Gordon Creek Wildlife Management Area is about 7 miles west/southwest of Helper, UT. It is a “nontypical” Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*) site. Soil

Table 7—Winter monoterpene (essential or volatile oils) content of current year’s growth of Hobble Creek big sagebrush. Data expressed as a percent of dry matter and as a percent of the total monoterpenoids. (Unpublished data on file at the Intermountain Research Station’s Shrub Sciences Laboratory, Provo, UT)

Monoterpene	Percent of dry matter	Percent of total monoterpenoids
Camphene	0.05	2.4
l,8 cineol	.60	28.7
Camphor	1.15	55.0
B-Thujone	.10	4.8
Fenchyl alcohol	.02	1.0
Oxygenated unknown	.17	8.1
	2.09	100.0

is of the Atrac series (Atrac is a fine sandy loam that usually occurs on 1 to 6 percent slopes). This soil is a deep, well-drained derivative of sandstone. Because of the sandstone parent material, this soil lacks the calcareous hardpan that is typical for most Wyoming big sagebrush habitat types (Winward 1983). Soil permeability is rapid with an effective rooting depth of 5 ft or more. The pH range is from 6.6 to 8.0. Average annual precipitation ranges from 12 to 14 inches. Frost-free period is 100 to 120 days (Utah State Engineer Office 1931-60; USDA SCS 1981).

‘Hobble Creek’ has also been grown successfully in Meeker, CO; Piceance Basin, CO; Challis, ID; and Tintic Valley, UT. The driest of these sites is Tintic Valley at 12 inches of annual precipitation (Utah State Engineer Office 1931-60).

‘Hobble Creek’ big sagebrush can be grown on sites with the following physical characteristics:

1. Mean annual precipitation of 14 or more inches. This is on the low end of the range for mountain big sagebrush (*A. t.* ssp. *vaseyana*). Monsen and McArthur (1985) reported a mean annual precipitation of 16.5 inches for eight Utah mountain big sagebrush communities.
2. Deep, well-drained soils with an effective rooting depth of at least 4 ft.
3. Soil no finer than clay loam (40 percent clay or less). On sites with heavy clay soils, mountain big sagebrush (this includes ‘Hobble Creek’) appears to be predisposed to root rot and vascular wilt type pathogens and soon dies (Nelson and Krebill 1981).
4. Soil pH between 6.6 and 8.6.
5. Growing season of 90 days or more.

We do not recommend trying to establish ‘Hobble Creek’ in Wyoming big sagebrush sites because of shallow soils and low precipitation (Winward 1983).

ESTABLISHMENT

'Hobble Creek' big sagebrush can be established on suitable sites by direct seeding, by transplanting bareroot or containerized stock, and by a technique we term "mother plant." Descriptions of the establishment techniques follow.

Direct Seeding

Direct seeding is the most practical method for establishing 'Hobble Creek' on areas larger than 10 acres. A successful direct-seeding program starts with the seed. Wildland seed quality and quantity varies greatly between years even if collected from the same site. 'Hobble Creek' seed is ready for collecting between mid-November and early December on the native site. This is also true for the 'Hobble Creek' seed increase plot located at Meeker, CO. However, due to the effects of heavy mule deer use, the native site is not a dependable source of 'Hobble Creek' seed. In one study, mature plants protected from heavy grazing (70 percent or more of the current year's growth) produced 30 to 50 times more seed stalks, and the stalks were 2 inches longer than the heavily grazed plants (Rodriguez and Welch 1986). Also, non-'Hobble Creek' big sagebrush needs to be kept 150 ft away from the seed garden to minimize or eliminate cross-pollination.

Harvesting 'Hobble Creek' seed from seed increase gardens can be accomplished by two hand techniques. One technique is to use sticks and to beat the ripened seed from the plants onto hand-held canvas hoppers. After proper drying, this material is run through a barley debearder. This procedure breaks stems so that seed cleaning is facilitated. However, it should be done rapidly so that seeds are not overheated. Further cleaning by passing materials through a series of screens will remove larger inert materials. This technique is fast but does not collect all available seed and will not work on less than fully ripened seed. When stormy weather is approaching and the seed is not fully ripened or to maximize the amount of seed harvested, another technique may be needed. The alternate technique is to cut the seed stalks off with clippers. The seed stalks are placed in heavy-duty plastic bags or other suitable containers and transported to drying racks, benches, or tables. Seed stalks must be air dried to prevent the development of mold and to reduce the tendency to ball up when cleaning the seed. Large stems can be separated from the seed and chaff by hand stripping. After stripping, the seed and chaff are passed through a series of screens that remove the fine stems and larger particles of chaff.

Sagebrush seed is normally collected with about 10 to 15 percent purity (Plummer and others 1968). Greater purities are possible, up to 95 percent and more, if the users are willing to pay the extra cost for cleaning. Storage life of big sagebrush seed in an open warehouse without temperature or humidity controls is about 5 years (Stevens and others 1981). Seed lots must be tested for germinability before being used in a direct seeding program regardless of age.

After a suitable site has been chosen, the next step in a successful direct-seeding program is site preparation. This could be total removal of all existing vegetation or partial

removal as with interseeding (strips 2 ft wide, spots 1 ft², or small patches). Vegetation can be removed or reduced by wild or prescribed fire, by mechanical means (roto-tillers, plows, disks, harrows, anchor chains, and so forth), or by chemical means. The amount of vegetation removal will depend on the amount and kinds of other forage species to be seeded with the 'Hobble Creek' big sagebrush. Seedbed preparation for big sagebrush is not as intense as for other forage species. It requires only competition control during germination and establishment. The amount of seedbed preparation will be dependent on the species in the mixture requiring the greatest amount of soil tilling. We do recommend planting 'Hobble Creek' big sagebrush in mixtures with other forage species because mixtures are more productive than monocultures, are able to extend season of use, and are more resistant to diseases and insects. Winward (1983) pointed out that mountain big sagebrush often occurs in floristically rich plant communities. The mixture should, however, be so constructed that 'Hobble Creek' will be dominant.

After site and seedbed preparation, the next chore is to sow the 'Hobble Creek' or seed mixture. This means choosing the time and depth of seeding. 'Hobble Creek' seed on the native site is wind-dispersed around the first part of December. Therefore, we believe the optimum time to sow the seed is just before the first accumulation of snow (see Young and Evans 1986 for additional information). Most species that are desirable to be planted with 'Hobble Creek' can also be sowed at this time.

Planting depth will vary according to species. For 'Hobble Creek,' surface or near-surface sowing on a firm seedbed is recommended. In greenhouse studies seedling emergence is near zero when 'Hobble Creek' seeds are planted deeper than 5 mm (Jacobson and Welch 1986). This also appears to be the case with other selections of sagebrush (Kelsey 1986; Young and Evans 1986). Frost heaving and the expansion and contraction of the soil surface due to wetting and drying will apparently cover the sagebrush seed enough for germination and establishment to take place.

'Hobble Creek' seed can be sown by aerial seeders, cyclone seeders, dribblers, and drills that have been adjusted not to cover the seeds. When using a drill, Richardson and others (1986) recommend that sagebrush and other shrubs be planted separately, in different rows, from the grass and forb species. Due to their quick development, grasses and forbs can cause detrimental competition in shrub establishment. This planting technique requires less shrub seed. Competition from the other forages is apparently not as much of a problem when aerially or broadcast seeded onto a prepared seedbed because of the more diverse microhabitat available for seed placement (Young and Evans 1986).

Amount of 'Hobble Creek' seed to be sown is more difficult to recommend and was the source of a vigorous debate among authors and reviewers of this manuscript. The reason for this debate is the lack of definitive studies and a definition of what constitutes a satisfactory sagebrush stand. Published rates range from 0.1 lb per acre to 0.85 lb per acre of pure live seed (Plummer and others 1968; Richardson and others 1986; personal communications). The senior author favors at least 0.25 lb per acre of

pure live seed. This is based partly on the assumption that ‘Hobble Creek’ is the most important species in the planting mixture. Utah Division of Wildlife Resources recommendations are 1 to 1.5 lb (10 percent purity, minimum of 65 percent germination) per acre which is equivalent to 0.065-0.098 lb of pure live seed per acre in a mixture that includes adapted shrubs, forbs, and grasses. Definitive studies are being planned.

Other direct seeding information: When interseeding behind a modified plow or scraper, best growth was found to be on the most shallow scalping treatment (Stevens 1985). Also, good results have been obtained by spraying strips with a broad-spectrum herbicide such as Round-up® followed by light harrowing and broadcasting the seed on the strip. Seedlings resulting from direct seeding projects may need protection from heavy grazing by wintering domestic sheep or mule deer for 2 or 3 years (Hunter and others 1980).

Transplanting Bareroot and Containerized Stock

Because of the expense, the usefulness of transplanting bareroot or containerized stock is limited to small, critical areas—seed increase gardens or demonstration plots. Planting stock should be from 5 to 8 inches tall and overwintered in a nonheated nursery bed or lathhouse. Actual transplanting can occur as soon as the frost has left the soil and the soil is tillable. We highly recommend spring transplanting of properly hardened planting stock. However, summer transplanting of containerized stock can be successful if the transplants receive adequate irrigation during the first growing season. We do not recommend fall planting of bareroot or containerized stock because of the danger of frost heaving and the lack of dependable soil moisture. Nonhardened containerized planting stock, such as containerized stock grown in a greenhouse during late winter (January to March), needs to receive a couple of water stress treatments before being planted. Planting of this type of stock should be after the possibility of frost. Transplants planted after May 1 may need supplemental watering for the first year. Usually the wettest month of the year is April.

For each transplant, an area 0.5 to 1 ft² needs to be cleared only once of all grass, forb, or shrub competition. The key to proper competition elimination is the mixing of the soil and the killing of tops, roots, stolons, and rhizomes. This can be done with hand shovels, a two-operator power posthole digger, tractor posthole digger, and so forth. Soil must be packed firmly around the transplant. To enhance survival, a basin about 0.5 ft in diameter with the plant at the bottom of the basin (1 to 3 inches deep) could be constructed at this point. The basin would serve as a water catchment. For extremely critical areas and during dry periods, the basin could be filled with water. For containerized stock, it is a good practice to cover the top of the greenhouse plant-growing medium with 0.5 inch of native soil. This will prevent the greenhouse medium acting as a wick and drying out the transplant.

We recommend 7 ft of spacing between containerized or bareroot transplants (7- by 7-ft grid equals about 900 plants per acre). This spacing would allow for the growth of desirable understory species of grasses and forbs.

Where possible, the transplants should be protected from heavy grazing for two or three growing seasons (Hunter and others 1980). Planting of bareroot or containerized stock can be done with a modified tree planter (Stevens 1985). For those systems using a scalper or plowing action, workers should be careful to minimize removal or hilling of topsoil. Because topsoils are shallow on most western rangelands, excess removal or hilling could result in a great portion of the feeder roots developing in the subsoil, resulting in poor or slow growth. First year survival rates should be in the 80 percent or higher range.

Producing Containerized Stock

In producing containerized ‘Hobble Creek’ stock, we use a plant-growing medium composed of sphagnum peatmoss, horticultural vermiculite, sandy loam soil, and number 3 sandblasting grit. We screen the peatmoss and soil through 0.5-inch hardware cloth prior to mixing. The plant-growing medium formulation is four parts screened peatmoss, three parts vermiculite, three parts screened soil, and three parts sand. A package of fertilizer is added during mixing of the medium. (Table 8 lists the fertilizers and the quantities used.) Plant-growing medium and fertilizer is thoroughly mixed while dry in a concrete mixer. Next, water is added until the mixture can maintain a ball shape after being hand squeezed. After mixing, the plant-growing medium is transferred to a soil cart where it is treated with aerated steam. This treatment heats the medium to 175 °F for 30 min. Aerated steam treatment controls many soil-borne plant pathogens. We use the methods described by Nelson (1984) to produce disease-free containerized stock.

Next, the medium is cooled and moved into a clean potting room where it is placed in Tinus root-trainer books (21.5 in³; 1.5 by 2 by 7.25 inches). Tinus and other brands of root-trainer books having longitudinal grooves prevent spiraling of roots, which reduces balling of the roots. Also, the root tips are air pruned, which aids in reducing root balling. These root trainers are placed in sets of eight into wooden crates. We fill the root trainers firmly to 1 inch from the top. This space provides a water basin. We sow about five to eight ‘Hobble Creek’ big sagebrush seeds on the surface of the plant-growing medium and cover the

Table 8—Fertilizer mixture used in the production of containerized ‘Hobble Creek’ big sagebrush stock

Fertilizer	Amount¹
	Grams
Dolomite	176
Ground limestone	176
Horticultural gypsum	100
Calcium nitrate	32
Osmocote (slow release fertilizers N, P, K)	32
Super phosphate	26
Trace elements	5
Chelate iron	2

¹The amount of fertilizer indicated is for each cubic foot of plant growing medium.

seed 1/8 inch deep with number 3 sandblasting grit. A fogger is used first thing in the morning and last thing at the end of the working day to keep the seed moist until 2 weeks after germination.

For research purposes, we normally start our containerized stock near January 1. We lengthen the day through use of artificial light (14 hours) until mid-April. Greenhouse temperature is set at 72 °F (day) and 58 °F (night). By mid-April the stock is about 6 to 8 inches high and ready for hardening. Hardening is a two-phase process: one of water stressing the plants and another of exposing the plants to unfiltered sunlight and wind. Plants can be fully hardened in about 2 or 3 weeks. For habitat improvement, we recommend starting the containerized stock in July (greenhouse) and hardening in October and winter in a nonheated lathhouse. Stock should be planted on sites after frost has left the soil and the soil is tillable to take advantage of early (April) spring moisture.

The “Mother Plant”

This establishment technique is a combination of transplanting and natural seed dispersal. Transplants furnish the mother plants that in turn supply the seed for dispersal. This technique would be used after a fire or some other process that has destroyed the native sagebrush stand. The absence of residue seed from the native stand would greatly enhance the success of the technique. The “mother plants” are planted as containerized or bareroot stock on a 50- by 50-ft grid throughout the site. Why 50 by 50? Frischknecht (1962) reported that the mean maximum spread of sagebrush from a mother plant was 42 ft. The direction of spread was dependent on prevailing wind. Energy is then directed toward the establishment, maintenance, growth, and protection of the mother plants on an individual plant basis. This may include fertilization, irrigation, fencing, and so forth.

After 3 to 5 years the mother plants are mature enough to produce seed. Direct seeding methods are then applied. Mechanical or chemical means are used to reduce competition either in strips or spots. This technique is needed for stand maintenance where ‘Hobble Creek’ annually receives heavy use (70 percent or more of the current year’s growth); because heavy grazing reduces seed stock production by a factor of 30 to 50 times, and hence also seed production (Rodriguez and Welch 1986).

A summary word: ‘Hobble Creek’ big sagebrush is a highly preferred big sagebrush that can be established by several techniques and that can raise the level of energy, protein, phosphorus, and carotene in the diet of wintering domestic sheep and mule deer on those sites where it is adapted.

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Welch, Bruce L.; McArthur, E. Durant; Nelson, David L.; Pederson, Jordan C.; Davis, James N. 'Hobble Creek'— a superior selection of low-elevation mountain big sagebrush. Research Paper INT-370. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 10 p.

About 15 years of research and evaluation resulted in identification of a superior selection of big sagebrush (*Artemisia tridentata*) for use on mule deer and domestic sheep winter ranges. This selection can raise the level of energy, protein, phosphorus, and carotene in the diet of wintering sheep and mule deer. A. Perry Plummer discovered the plant in 1968 at the mouth of Hobble Creek drainage just east of Springville, UT. 'Hobble Creek' is a low-elevation mountain big sagebrush. We describe the need, nutrient profile, areas where it can be grown, disease relations, and establishment procedures for the selection.

KEYWORDS: winter range, nutritive value, establishment, revegetation, *Artemisia tridentata*, mule deer, domestic sheep

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